Evaluation of a Novel Periodontal Risk Assessment Model in Patients Presenting for Dental Care

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Purpose: The present study was designed to develop a new periodontal risk assessment model based on the periodontal risk assessment (PRA) model by Lang and Tonetti, and to evaluate the risk assessment capability of the proposed model.

Materials and Methods: Twenty-six patients diagnosed with chronic periodontitis were selected randomly and a thorough examination and charting of the periodontal status was performed. An intra-oral periapical radiograph of the area with the deepest probing depth was also taken. The following parameters were recorded: percentage of sites with BOP, number of sites with pocket depths ≥ 5mm, number of teeth lost, bone loss/age ratio, attachment loss/age ratio, diabetic and smoking status, dental status, other systemic factors and risk determinants. Using Microsoft Excel®, the parameters were plotted on the radar chart as per the original and the proposed model.

Results: Of the cases identified by the original model, 42.3% were high-risk cases and 30.8% of the cases were low-risk cases. In the proposed model, 46.2% of high-risk cases and 46.2% of low-risk cases were identified. Only 7.7% of the cases identified with the new model were moderate-risk cases. Statistical analysis demonstrated that there was no significant difference between the risk scores of the two models.

Conclusions: The results suggest that risk assessment by this model does not vary significantly as compared to the original model, and both are equally adept at detecting potential risk groups.

Key words: periodontal disease, periodontal risk assessment, risk assessment, risk determinants, risk factors

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Assessment of risk and applying this information in the prevention and treatment of periodontal disease is a tested and changing concept. Periodontal disease was initially thought to be a disease exclusively found in adults, but it is now generally agreed that differing susceptible patterns may exist in specific populations (Axelsson, 2004; Dentino et al, 2005). Thus a proper risk assessment model becomes a necessity to assess the risk caused by various forms of periodontal disease.

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There is a transition occurring in periodontics from a health care model to a wellness model (Page et al, 2003; Dentino et al, 2005) and in this context, the assessment of risk caused by periodontal disease becomes crucial and is an essential factor in treatment assessment and during maintenance phase.

Risk factor is defined as some aspect of personal behaviour or lifestyle, an environmental exposure, or an inherited characteristic that, based on epidemiological evidence, is known to be hazardous to one's health and well-being. Risk determinants or background characteristics are the risk factors that cannot be modified (Axelsson, 2004; Dentino et al, 2005).

When risk assessment is performed without the use of a risk assessment model, there is a great degree of variation between general dentists and periodontists and between periodontists themselves, which makes the development of risk assessment models impor-

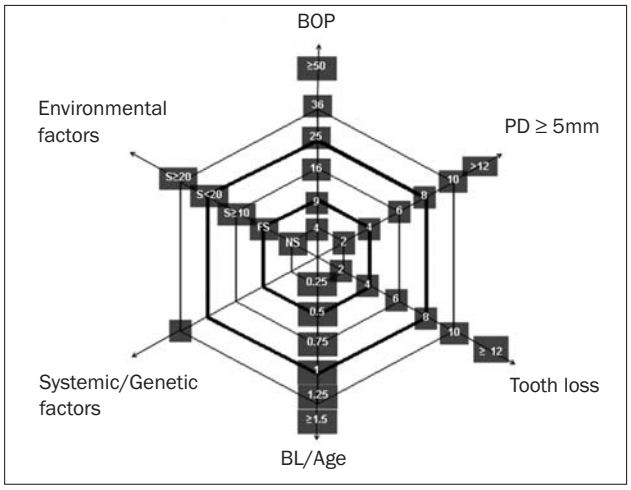

Fig 1 Lang and Tonetti's periodontal risk assessment (PRA) model (Lang and Tonetti, 2003; Lang et al, 2003).

tant, if not mandatory, for assessing risk (Page et al, 2003). Various risk assessment models are in vogue, which utilise different parameters for risk assessment. Different patient based factors are considered that might or might not contribute to the predictive ability of these risk assessment models. In addition, these models have been used prospectively or retrospectively to assess risk, thus confounding periodontists both in the selection as well as in the interpretation of data from a risk assessment model (Renvert and Persson, 2004). The method of generating a risk assessment polygon (or the pictorial representation of a risk assessment model) in itself may be a cumbersome process and may be too confusing for an average dental practitioner or student to understand (Page et al, 2003; Renvert and Persson, 2004). This may lead to a potential lack of understanding about these risk factors and the role they play in the initiation and progression of periodontal disease.

There is a lack of an uncomplicated risk assessment model that can be used conveniently by students, general dentists or periodontists. The present study was designed to develop a risk assessment model from a previously described model and to compare the risk assessment capability of the proposed model with the original model. The proposed new risk assessment model is easy to generate and obtain, uses retrospective and current data to assess the risk of periodontal disease and uses a simplified format on a scale of 0–5, in contrast to the original assessment model which is more complicated to use.

METHODS

Development of the model

The risk assessment model described is an expansion of the periodontal risk assessment (PRA) model by Lang and Tonetti (Lang and Tonetti, 2003; Lang et al, 2003). The details of the PRA model, hereafter referred to as the 'original model', are discussed elsewhere (Lang and Tonetti, 2003). It is a continuous multilevel risk assessment model that incorporates subjective tooth and site risk assessments and generates a functional diagram, and depending on the area of the polygon categorises the patient into low-, medium- and high-risk categories (Fig 1).

However, the original model has the following limitations:

- it mainly assesses the cumulative status of a periodontitis patient;
- there is no proper identification of risk factors and risk determinants;
- in the functional diagram, the presence of a systemic disease is assessed as a high-risk factor with no emphasis on the current status of a disease;
- smoking is assessed in the risk assessment model, but another potential risk factor, diabetes, is not assessed separately and is included in the systemic diseases category;
- it does not take into account the various dental factors, which may modify or initiate the progression of periodontal disease.

Four entities from the original risk assessment model were retained in the new model: bleeding on probing (BOP), probing depth, tooth loss and smoking (the latter was described under 'environmental factors' in the original model). The entities that were added in the new model included various aspects of risk assessment, especially risk factors (diabetes, and tooth deposits or factors that may retain deposits) and other risk determinants such as socio-economic factors and stress (Page and Beck, 1997).

From the visual standpoint, the new model is similar to the recent models developed for combined caries–periodontal disease risk assessment (Axelsson, 2004). These models use parameters such as external modifiers, which include smoking, use of various forms of tobacco, low socio-economic level, infectious and other diseases, side effects of medication and poor dietary habits; and internal prognostic factors such as genetic factors, chronic diseases, impaired host factors and reduced salivary flow. The combined caries–periodontal disease risk assessment

models assess risk on a 0–3 colorimetric scale and also include separate criteria for caries and periodontal disease for risk assessment.

The risk assessment model was developed using Microsoft Excel® and includes eight parameters:

1. Percentage of sites with BOP
2. Number of sites with probing depth (PD) ≥ 5 mm
3. Number of teeth lost
4. Attachment loss (AL)/age ratio
5. Diabetic status
6. Smoking
7. Dental status – systemic factors interplay
8. Other background characteristics

BOP, PD, tooth loss and AL/age ratio measure the cumulative periodontal status, which is the present status of the individual due to periodontal disease. Diabetic status and smoking are the risk factors, and stress and socio-economic factors are the risk determinants, that were assessed in this new model. However, all of these parameters were assessed on a five-point risk scale to balance the sensitivity of risk assessment with the time and expertise required to collect the required information (Fig 2) (Page et al, 2003). The criteria for four entities in the original risk assessment model, namely BOP, PD, tooth loss and smoking, were retained in the new model, but the scoring criteria for these entities were adapted on the lines of Renvert and Persson (2004) (Table 1).

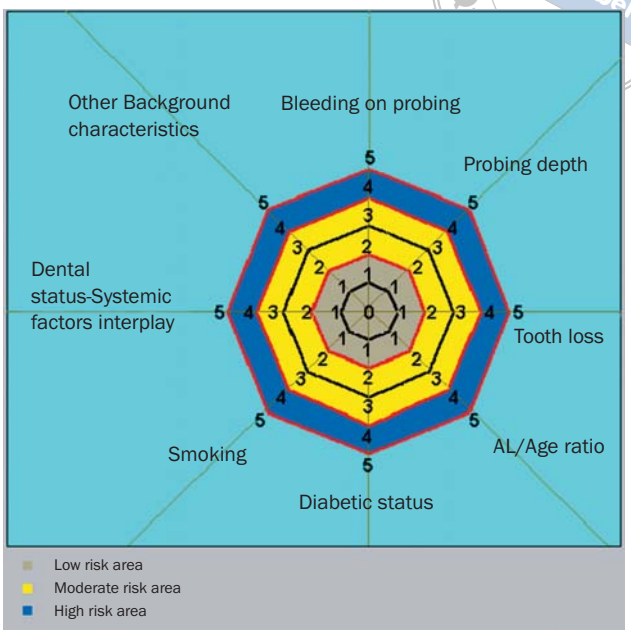

Fig 2 The proposed model, which considers the cumulative periodontal status, risk factors and risk determinants under eight parameters and with clearly demarcated low-, medium- and high-risk zones.

Smoking and tobacco use

The number of smoking packs/year was followed in Renvert and Persson's model (Renvert and Persson, 2004). This is confusing because different countries have different number of cigarettes in a pack (Kaldahl et al, 1996). Hence the scoring criteria was modified to cigarettes/day, to take into account this possibility (Table 1).

Replacement of bone loss with attachment loss

In the original risk assessment model, bone loss (BL)/age ratio was considered to assess the risk, and the measurement of BL on a standardised radiograph

Table 1 Coding system for BOP, sites with PD ≥ 5mm, tooth loss, smoking, AL/age ratio and diabetic status

Axis score	BOP (%)	No. of sites with PD ≥ 5mm	Tooth loss	Smoking (cigarettes/day)	AL/age ratio	Diabetic status (Fasting glucose in mg/dl)
0	0	0	0	Non-smoker (NS)	0	<102
1	≤ 4	1–2	1–2	Former smoker (FS)	≤0.25	102–109
2	5–9	3–4	3–4	<10	0.26–0.5	110–117
3	10–16	5–6	5–6	10–19	0.51–0.75	118–125
4	17–25	7–8	7–8	20	0.76–1.0	126–133
5	>25	>9	>9	>20	>1	≥134

Table 2 Coding system for dental status – systemic factors interplay

Axis score	Status
0	Healthy
1	Healthy with minor dental problems not affecting periodontium
2	Dental health problems affecting the periodontium including iatrogenic, endodontic, prosthodontic and orthodontic problems
3	General health problems that might modify the progression of periodontal disease including genetic, nutritive, endocrine, haematologic, immunodeficiency and psychosomatic disorders, including risk indicators like HIV and osteoporosis
4	Severe dental problems in the presence of diseases that can modify periodontal diseases
5	More severe than above and associated with severe tooth morbidity

Table 3 Coding system for background characteristics

Axis score	Socio-economic status	Stress
0		No stressful environment
1	Upper white-collar worker	Mildly stressful environment. However, patient can easily fall asleep
2	White-collar worker	Moderately stressful environment/traumatic first 15 years/difficulty in falling asleep
3	Blue-collar worker	Traumatic episode within last 7 years/lacking full night's sleep/highly restless
4	Temporary/ Contract employment	Traumatic episodes within a year/severe lack of sleep/intensely restless
5	Unemployed	Very stressful environment

was recommended. BL can be equated with AL although it succeeds it by 6–8 months (Gutman, 1978; Goodson et al, 1984). Measuring BL in radiographs may be time-consuming, unlike assessing AL. This would not affect the risk assessment as AL measurements and radiographs suffer from the same problem of lacking predictive power for periodontal breakdown (Yang et al, 1992). Loss of attachment and loss of alveolar bone generally increase with aging, but pocket deepening may not correlate with these changes (Yoneyama et al, 1988), thus the number of sites with PD ≥ 5 mm may be important, but not the PD per se. Therefore AL/age ratio was assessed on a five-point scale (Table 1).

Diabetes

The most substantiated evidence for the modification of disease susceptibility to progression arises from type I and type II diabetes mellitus (Genco and Loe, 1993). The graduations are in a linear, non-quadratic form (Table 1) and correspond to the values usually used for the diagnosis of the disease in various diagnostic tests (American Academy of Periodontology, 2000). A value of fasting glucose less than 110 mg/dl implies low risk, and more than 126 mg/dl implies high risk. Any value in between implies a medium risk. This can be substituted with values for random glucose, or impaired glucose tolerance, although glucose

tolerance is not recommended (Genco and Loe, 1993; American Academy of Periodontology, 2000; Mealy et al, 2003). Although not a parameter in most of the risk assessment models, diabetes is one of the risk parameters in Page et al's (Page et al, 2003) periodontal risk calculator (PRC).

Dental status – systemic factors interplay

Numerous other health problems may modify the progression of periodontal disease and the host response may vary between an inadequate response and an exaggerated response (Klokkevold et al, 2003). Likewise, tooth risk factors such as iatrogenic factors, furcation invasion and other factors also play a role in predisposing and accelerating periodontal disease. These may act as potential plaque-retaining areas, which may be periodontopathic, especially if systemic disease is present (Page and Beck, 1997). Assessment of the systemic and the local factors separately may be time-consuming. For the proposed new model, a five-point scale running in a linear mode was developed by adapting it from a questionnaire based on a study for the assessment of various dental and systemic factors (Axtelius et al, 1998) (Table 2).

Other background characteristics

Genetics, age, gender, stress and socio-economic status are the important background characteristics, and are also called risk determinants (Axelsson, 2004; Dentino et al, 2005). Genetic factors may predispose a person to develop periodontitis (Michalowicz et al, 1991), although this aspect is controversial. Lang and Tonetti (2003) recommend that genetic factors should be marked in the high-risk area. This, however, has its limitations:

- commercially available genetic kits are difficult to obtain or are unreliable to correctly assess the risk caused when a genetic factor is present;
- marking the risk on the assessment model may mask the importance of the other components of the risk assessment model;
- when a genetic testing kit is not at hand, no guidelines exist on how to assess risk when a genetic factor is present.

However, hereditary factors may account for approximately 50% of the risk for developing periodontal disease (Michalowicz et al, 1991), and its importance cannot be underestimated. Hence, in this model, the

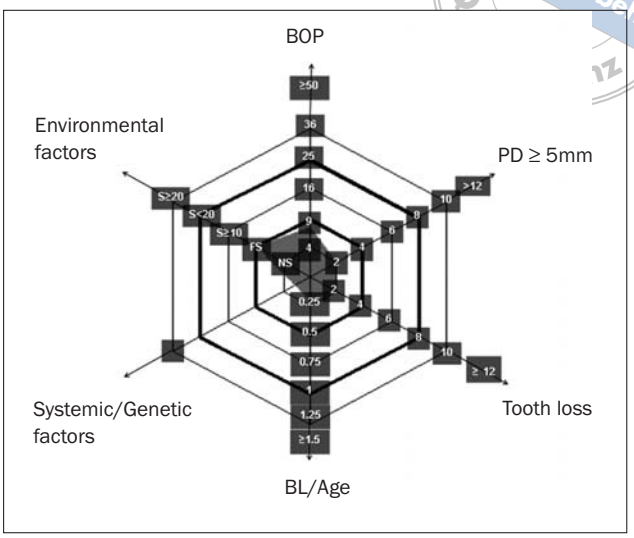

Fig 3 A low-periodontitis-risk patient: 7% of sites with BOP, 2 sites with PD ≥ 5mm, 2 lost teeth, a BL/age ratio of 0.24 and a former smoker.

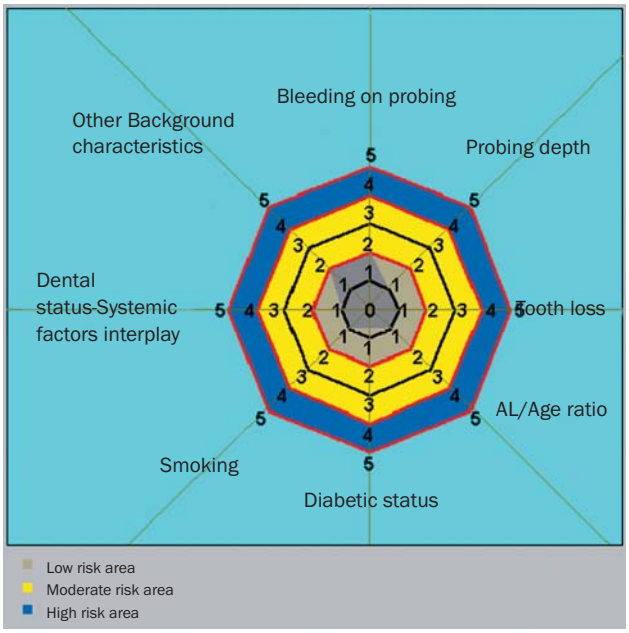

Fig 4 Risk diagram of the same low-periodontal-risk patient shown in Fig 3, with pit and fissure caries on the molars (minor dental problems not affecting periodontium) and with difficulty in falling asleep.

genetic component, if present, is marked under the dental status – systemic factors interplay (Table 2). Socio-economic status and stress are the other important background characteristics that must be assessed to know the risk of periodontal disease. Age is already addressed in the AL/age index. Socio-eco-

nomic status also pertains to the decreased awareness of oral health and decreased dental visits (Genco and Loe, 1993). This parameter in the proposed model is assessed on a gradated scale adapted from the questionnaire of Axtelius et al (1998) (Table 3). Stress was evaluated based on the examiner's subjective impression of stress level using a 1–5 scale.

All the parameters were checked and marked on the assessment model. Risk is assessed as follows:

- A low-periodontal-risk patient has all the parameters in the low-risk area, or at the most two parameters in the moderate and high-risk area. This is similar to the original assessment model, where all the parameters must be in the low-risk category or at the most one parameter in the medium-risk area (Figs 3 and 4).
- A moderate-periodontal-risk patient has at least three parameters in the moderate-risk area and not more than one parameter in the high-risk area, as opposed to the original assessment model in which two parameters must be in the moderate-risk category and not more than one parameter in the high-risk category. However, the presence of one parameter each in moderate- and high-risk areas in the original model was also considered as a moderate-periodontal-risk case (Figs 5 and 6).
- A high-periodontal-risk patient has at least two parameters in the high-risk category, which differs from the original model in that only two parameters must be in the high-risk category (Figs 7 and 8).

Evaluation of the proposed risk assessment model

Twenty-six patients diagnosed with chronic periodontitis were selected randomly, and a thorough examination and charting of the periodontal status was carried out. An IOPA (intra-oral periapical radiograph) of the area with the deepest PD was also taken. To prevent examiner variability, a single examiner (RVC) performed the charting and examination. The parameters recorded were: percentage of sites with BOP; number of sites with PD ≥ 5 mm; number of teeth lost; BL/age ratio; AL/age ratio; diabetic and smoking status; the parameters required for the dental status – systemic factors interplay; and the risk determinants. Using Microsoft Excel®, the parameters were plotted on the radar chart as per the original and the proposed model and the risk status was assessed.

RESULTS

The group was 62% male, had a mean age of 42.3 years and had an average of 26.65 teeth. Eight subjects were smokers, and one patient was a former smoker. Two patients were confirmed diabetics, five patients had liver diseases because of alcoholism and other causes. Three patients were under extreme stress because of monetary and health concerns, two patients had experienced a traumatic episode within the last 7 years and three patients had difficulty in falling asleep and were under medication for this. However, only six patients had undergone some form of periodontal therapy.

Eight low-risk, seven moderate-risk and 11 high-risk cases were identified by the original model, whereas 12 low-risk, two moderate-risk and 12 high-risk cases were identified by the proposed model. Approximately 42.3% of the cases identified by the original model were high-risk cases, whereas 30.8% of the cases were low-risk cases. In the proposed model, 46.2% were identified as high-risk and 46.2% were identified as low-risk cases. Only 7.7% of the cases identified in the new model were classified as moderate-risk cases (Table 4). Thus the number of high-risk cases identified by the original and the proposed models were similar (42% and 46% respectively), but the original model identified more moderate-risk cases than the proposed model. The new model could identify more low-risk cases than the original but identified only two moderate-risk cases.

However, statistical analysis of the overall scores by the Chi-square test demonstrated that there was no statistically significant difference between the risk scores of the two models ($\chi^2 = 3.621$, $p = 0.164$). This implies that risk assessment by this model does not vary significantly when compared with the original model and is as adept as the original model in detecting potential risk groups.

DISCUSSION

The present study was designed to develop a risk assessment model based on a previously described model and to compare the risk assessment capability of the proposed model with the original model. However, various risk assessment models have been previously developed before and are in vogue. They range from a simple questionnaire (Schutte and Donley, 1996) to a more complicated PRC (Page et al, 2003). The PRC evaluates nine risk parameters on a scale of 1–5, namely patient age, smoking, diagnosis of dia-

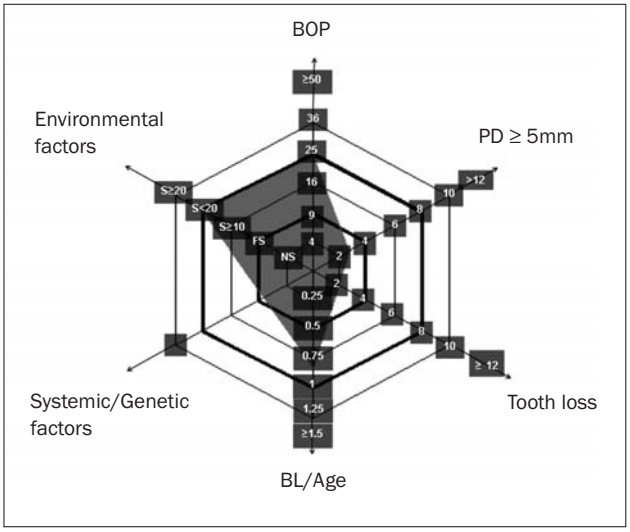

Fig 5 A moderate-periodontitis-risk patient: 25% of sites with BOP, 3 sites with PD ≥ 5mm, 2 lost teeth, a BL/age ratio of 0.8 and an occasional smoker.

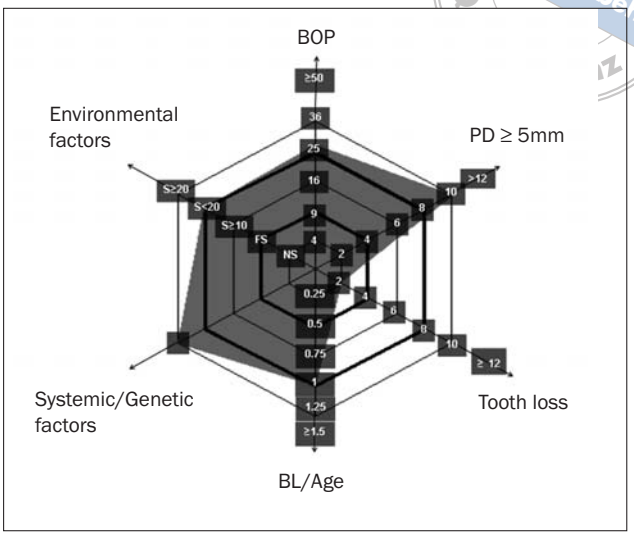

Fig 7 A high- periodontitis-risk patient: 27% of sites with BOP, 10 sites with PD ≥ 5mm, 2 lost teeth, a BL/age ratio of 1, diabetic and an occasional smoker.

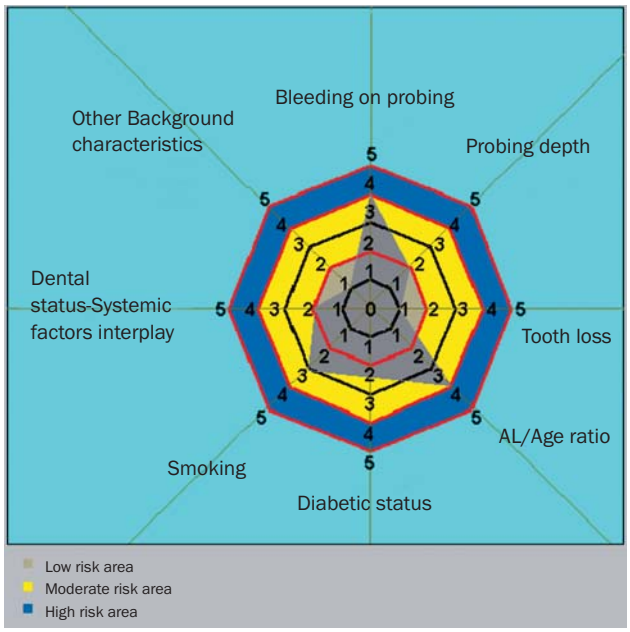

Fig 6 Risk diagram of the same moderate-periodontal-risk patient shown in Fig 5, with an overextended restoration and living in a stressful environment.

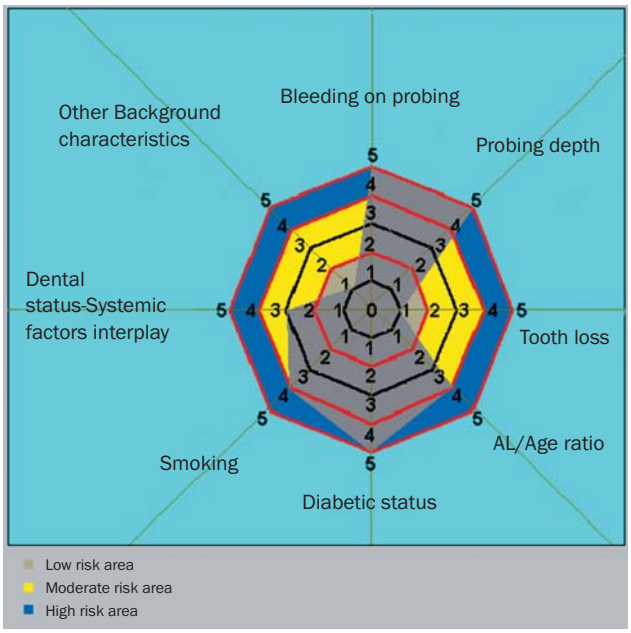

Fig 8 Risk diagram of the same high-risk periodontal patient shown in Fig 7, with a fasting blood glucose level of 167 mg/dl, periodontal abscess and living in a stressful environment.

betes, history of periodontal surgery, PD, furcation involvements, restorations or calculus below the gingival margin, radiographic bone height and the presence of vertical bone lesions. According to the authors, risk scores calculated using PRC and information gathered during the standard periodontal examination predict risk with a high level of accuracy.

Another risk assessment tool is the Oral Health Information Suite (OHIS) (Page et al, 2005), which according to the authors provides quantitative information to the clinician and patient as an aid to diagnosis and to facilitate individual, needs-based treatment planning. The authors of the OHIS also state that it enables successful application of the wellness model of

Table 4 Distribution of high-, moderate- and low-risk cases according to the original and the proposed models

Model	Risk type			Total
	High risk	Low risk	Moderate risk	
Original model	11 (42.3%)	8 (30.8%)	7 (26.9%)	26 (100%)
Proposed Model	12 (46.2%)	12 (46.2%)	2 (7.7%)	26 (100%)

oral health care, which may be expected to result in more uniform and accurate clinical decision making, improved oral health, reduction in the need for complex periodontal therapy, reduction in oral healthcare costs, and improved clinician productivity and income.

However, Persson et al (2003) stated that differences exist on the scale of risk values based on specialty training. Consistency in the scoring patterns exist but they stated that risk scores generated for individual patients may be highly variable and may result in misapplication of treatment for some patients. The proposed model, as compared with that of the PRC, has some similarities: diabetes is evaluated and the graduations correspond to the recommended values pertaining to the diagnosis of diabetes on a linear scale; also, the importance of restorations and other dental factors are evaluated on a scale of 0–5. Thus the risk that these factors might cause can be easily assessed. However, patient age is considered under AL/age ratio, and radiographic bone height and vertical bone lesions have not been considered as they may be difficult to assess and may be time-consuming. The PRC is essentially a computerised tool, and after the information is sent to the parent server, a complete patient report can be obtained by the periodontist. The assessment polygon of the proposed model can be generated easily by using Microsoft Excel® and, alternatively, a printout can itself be used in risk evaluation as all the parameters are on a 0–5 scale, thus facilitating easy scoring. Moreover, the PRC assesses risk prospectively whereas the proposed model assesses risk based on the cumulative and retrospective data.

In the proposed model, all the parameters were evaluated on the scale of 1–5, with the scoring criteria loosely based on those of Renvert and Persson (2004) for the parameters in Lang and Tonetti's model, in which all the parameters were coded from 0–5 depending on the clinical situation and findings (Lang and Tonetti, 2003). Renvert and Persson (2004), however, excluded systemic/genetic factors in the assessment model and considered only five parameters.

Regardless of the risk assessment model used, it should be emphasised that the predictive value of most of the routine periodontal parameters is low (Persson et al, 2003). One example is BOP, where its presence is highly significant if the prevalence is ≤ 25%, but higher levels of prevalence cannot be used as a predictor of disease progression (Joss et al, 1994). However, deeper periodontal pockets and PD are positively associated with the progression of periodontitis (Beck et al, 1997). Hence parameters like BOP and PD must be interpreted with care and caution. Several studies have suggested that radiographic information in relation to the subject age is important when assessing periodontal status (Persson et al, 1998), but it is important to note that AL was substituted for BL to simplify the assessment, as it would not require an IOPA and the time taken for the assessment would be reduced.

The new model assessed in this study tries to incorporate both local and systemic factors, including dental factors that can initiate and modify the progression of periodontal disease and certain risk determinants. Local factors include bacteria and any niches, natural or iatrogenically created, that can harbour periodontopathic bacteria, which, if left undisrupted, can initiate periodontal disease. This dental factors–systemic disease interplay tends to emphasise the importance of these factors, especially in the presence of systemic conditions that may modify the normal neuro-endocrinological mechanisms, which make up the normal host response (Seymour, 1991; Wilson and Kornman, 2003). Socio-economic status and stress are the other important background characteristics, which must be assessed to know the risk for periodontal disease. Socio-economic status also re-

lates to decreased awareness and decreased dental visits (Genco and Loe, 1993). There is an apparent association between psychosocial factors and risk behaviours such as smoking, poor oral hygiene and periodontitis (Axtelius et al, 1998; Novak and Novak, 2003). Although epidemiological data on the relationship between stress and periodontal disease is limited, stressful events appear to lead to a greater prevalence of periodontal disease (Green et al, 1986). However, there is a clear need for longitudinal prospective studies that address hypotheses emerging from the cross-sectional data and include established risk factors as covariates along with new exposures of interest (Borrell and Papapanou, 2005).

The original model identified more moderate-risk cases, whereas the proposed model identified a higher percentage of low-risk cases and could identify only two moderate-risk cases. This can be attributed to two reasons: the higher number of parameters in the proposed model (8 and 6 respectively); and the criteria used for risk assessment. In the proposed model, for a patient to be identified as a moderate-periodontal-risk patient, at least three parameters must be present in the moderate-risk area and not more than one parameter should be present in the high-risk area; whereas in the original assessment model, classification as a moderate-periodontal-risk patient requires that two parameters must be in the moderate-risk category and not more than one parameter in the high-risk category. Thus the presence of two parameters in the moderate-risk area would qualify as a moderate-periodontal-risk patient in the original model whereas it would qualify as a low-risk case according to the proposed model.

Statistical analysis demonstrated that there was no statistically significant difference between the risk scores of the two models. The following conclusions can be drawn by the statistical analysis. In general, the proposed model differs from the original model in two ways: the inclusion of new parameters and the alteration of existing parameters. The results suggest that the addition of new parameters may not alter the risk assessment capability of the model. Certain changes, such as the replacement of the BL/age ratio with AL/age ratio also did not alter the risk assessment capability of the model, which can be loosely attributed to the fact that AL can be correlated to the BL (Yoneyama et al, 1988; Yang et al, 1992).

In the evaluation of the natural progression of periodontal disease, prospective studies are generally preferred over retrospective studies (Renvert and Persson, 2004), and some risk assessment models have been assessed for their effectiveness in predicting the future periodontal status (Page et al, 2003). However, the new model was not assessed in this way and the model is primarily a retrospective one where information is gathered to assess the current risk for a patient, unlike other models where current status is assessed and future risk is predicted.

In conclusion, a novel periodontal risk assessment model is described and compared to the model from which it is derived (PRA). The proposed risk assessment model is easy to generate and obtain, uses retrospective and current data to assess the risk of periodontal disease and uses a simplified format on a scale of 0–5 for periodontal risk assessment. The results suggest that risk assessment by this model does not vary significantly when compared with the original model and both are equally adept at detecting potential risk groups. The use of a risk assessment tool over time may be expected to result in a more accurate periodontal clinical decision-making, improved treatment protocols and indirectly would result in the reduction of complex therapies and would prevent the future effects of periodontal disease such as bone and tooth loss.

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